On-Scene Analysis/Forecast System

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LONG-TERM GOAL

Develop and demonstrate an end-to-end, on-scene analysis/forecast system for real-time data fusion, analysis, and forecasting. This system will be used to produce tactical atmospheric parameters that affect weapon and sensor systems and will be designed to use a local area network interfaced to automated instruments, a modern database, and supporting software.

OBJECTIVES

Develop the framework for an analysis, nowcast, and short-term forecast system that can be used at on-scene locations. This development will include optimal objective analysis methods that blend all observations and dynamical constraints into a 3-dimensional depiction of the atmosphere; methods to include new data sources (e.g., in-situ, remotely sensed observations) into existing analysis methods; quality control methods for on-scene observations to insure time and space continuity; initialization procedures to reduce high-frequency oscillations resulting from initial imbalances of analyzed data; a procedure for flexible and efficient execution of inner grids (e.g., starting time, location); and a hierarchy of physical parameterizations that allow a choice between computational time and sophistication. The performance of the system will be evaluated, and studies will be performed to determine the impact of simplified model physics and/or code optimization to meet time constraints.

APPROACH

Our approach is to use the atmospheric component of the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) as the framework for the on-scene system. Modifications and/or additions to this system for on-scene applications on different computer platforms, with different options for execution, include:

1. Build an atmospheric data assimilation system that will be able to analyze mesoscale weather by applying sophisticated analysis procedures capable of ingesting the information from conventional and non-conventional observations.

2. Develop general algorithms to allow for portability of the on-scene system between hardware platforms, including both shared and distributed memory systems while maintaining high performance on each platform within one single-code version of the system.

3. Build alternative and/or simplified physical parameterization packages to allow timely short-term forecast using on-scene computer systems.

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4. Develop procedures to allow flexible execution of inner high-resolution grids at delayed starting time and allow multiple nested domains at the same level of grid configuration.

5. Link the analysis and forecast model output to METOC decision aids via the Tactical Environmental Data Subsystem (TEDS) data base, a component of the Tactical Environmental Support System/Next Century (TESS/NC), that provides the network interface to tactical computer systems.

6. Develop a “warm start” capability for the on-scene to begin the local data assimilation cycle from COAMPS forecast products produced at another remote center.

7. Develop/convert the code for the system to utilize new technologies in computer and communication environment that become available.

WORK COMPLETED

The system has been ported and run successfully to various workstation environments with differing number of processors as well as the Window NT environment.

Two initialization procedures have been built for the on-scene system that include digital filter and dynamic initialization to remove high-frequency oscillations resulted from imbalances in the analyzed fields. Physical initialization is incorporated in the diabatic forward integration of the dynamic initialization cycle to adjust the initial moisture field using the in situ and/or remote-sensed rainfall rates (amounts).

Some algorithms of the forecast model have been found to be cache memory inefficient while others exhibit poor scalability. Modification of the algorithms was made to alleviate some of these problems by reducing the length of long loops that involve many two- and three-dimensional arrays to reduce the cache conflict problem. Restructuring of the algorithms continues.

Capability of flexible starting time of the inner grids has been built for the system. Since the integration of inner grids usually takes more than two third of the total computation, delayed starting of the inner grids saves significant amount of time.

The system has been upgraded for generalized input fields for initial and boundary conditions. This allows the on-scene system to use analyzed and forecast fields from variable grid resolution of NOGAPS as well as fields of COAMPS that covers a greater area than its own domain.

The Kain-Fritsch scheme was improved for faster execution time and improved representation of physical processes. They include pre-checking of convective instability and determining of the cloud temperature by mixing the updraft and environment flow. A simplified radiation scheme was coded for the on-scene system that considers the radiation effect to terrain temperature only. The execution time for the simplified radiation scheme is negligible compared to the full radiation scheme.

RESULTS

The upgraded on-scene system has been ported successfully to a variety of workstations and Window NT environment. The results have been verified against the operational FNMOC version of the code. The improved portability assures code consistency and maintainability across platforms.

The capability of a delayed starting time for the inner grids reduces the executing time substantially, depending on the difference between the initial time of the outer grids and the starting time of the inner grids. Modification of the code and compiler options leads to an improvement of 31% in the throughput of the no-scene system.

The improved Kain-Fritsch scheme for cumulus parameterization reduced 40% of the CPU time used in cumulus parameterization. Performance of the new version has been tested for two-week period over continent U. S, central Europe, and equatorial region near Australia. Overall, the new version produces slightly larger amount of precipitation, an improvement over the old scheme. Statistics of the forecasts are improved over the U. S. but are slightly reduced over Europe.

The incorporation of rainfall rates at the initial time through physical initialization reduces the spin-up problem associated with the imbalance between mass and momentum fields. Long-term impacts of including the rainfall rates through physical initialization will be investigated.

The improved flexibility of input data structure for the on-scene system allows the system to run high-resolution grids using the analyzed and forecast fields from COAMPS that cover a larger domain. The system can also start up from the NOGAPS fields with different resolutions.

The on-scene system has been tested with reduced computation of physics. Comparing with the full radiation scheme, the simplified radiation scheme produces inferior statistics for an extended period of simulation. Reduced computation of microphysics from every time step to every two time-steps also degrades the performance of the model. It is recommended that the efficiency of the system should be obtained by improving the algorithms instead of simplifying the model physics.

IMPACT

The success of COAMPS in the on-scene environment is significant and has been recognized by CDR David G. Markham as "… a monumental achievement that will undoubtedly have a far-reaching impact on our future METOC CONOPS." The continued effort on the improvement of the system to allow assimilation of in-situ and remote-sensed data, and initialization procedures to remove initial imbalances, more flexible execution capability, and a more efficient forecast model, will warrant successful application of the on-scene system to provide timely atmospheric conditions for Navy missions.

TRANSITIONS

Developments from this program transition to an existing 6.4 program (PE 0603207N) for applications within TESS/NC and, via the TESS/NC - JMCIS link, with the tactical applications supporting on-scene decision-makers.

RELATED PROJECTS

Related 6.2 projects within PE 0602435N are BE-35-2-18, for the development of atmospheric mesoscale models, BE-35-2-19, for the development of data assimilation techniques, and T045-99, an effort to understand and develop better moisture, cloud, and precipitation forecasting techniques. The related 6.4 project under PE 0603207N focuses on the transition of the 6.2 development to the TAMS/RT demonstration project.

IN-HOUSE/OUT-OF-HOUSE RATIOS

100% in-house, 0% out-of-house.